The Venetian Alps thrust belt

C. Doglioni

Dipartimento di Scienze Geologiche e Paleontologiche, Università di Ferrara, 44100 Italy

Abstract: The Venetian part of the Southern Alps (N Italy) is a Neogene south-vergent thrust belt. The minimum shortening of the chain is 30 km. The thrusts trend N60°-80°E and show an inherited N10°W-N10°E normal fault pattern of the Mesozoic continental margin. These earlier features strongly controlled the evolution of the following oblique thrust belt. Structural undulations along strike of folds and thrusts occur in correspondence to Mesozoic faults, thickness and facies variations. The thrusts are arranged in an imbricate fan geometry. A frontal triangle zone laterally ends at transfer faults. Earlier stages of the thrust belt were characterized by frontal triangle zones which have later been involved and cut by the progression of the internal thrusts.

This paper describes the main structural grain of the Venetian Alps (Figs 1 & 2), a part of the Southern Alps, south of the Insubric Lineament. It is a SSE-vergent fold and thrust belt of mainly Neogene age (Dal Piaz 1912; Leonardi 1965; Castellarin 1979; Laubscher 1985, Massari *et al.* 1986; Roeder 1989; Doglioni 1987) probably produced by the dextral transpression in the central-eastern Alps (Laubscher 1983). The chain (Fig. 3) deformed a pre-existing Mesozoic passive continental margin (Aubouin 1963; Bosellini 1965; 1973; Bernoulli *et al.* 1979; Winterer & Bosellini 1981).

The study area has been shortened mainly during Neogene times (Venzo 1939; Massari *et al.* 1986; Doglioni 1987) and not deformed by the Dinaric chain which constituted the unfolded foreland during Palaeogene times (Doglioni & Bosellini 1987).

Inherited structures

The Southern Alps were part of a Mesozoic continental margin, according to stratigraphic analysis, i.e. facies and thicknesses changes (Bernoulli *et al.* 1979; Winterer & Bosellini 1981). The area can be divided into three main structural sectors during the Mesozoic. These are, from west to east: the Trento Platform, the Belluno Basin and the Friuli Platform. True Mesozoic normal faults (i.e. Liassic) have been documented at the western border of the Trento Platform (Castellarin 1972; Doglioni & Bosellini 1987) and at its eastern margin (Winterer & Bosellini 1981; Bosellini *et al.* 1981; Bosellini & Doglioni 1986; Masetti & Bianchin 1987, Doglioni & Neri 1988).

The Mesozoic normal faults trend mainly N10°W-N10°E. It can be argued that the Trento Platform, the Belluno Basin and the Friuli Platform were bounded by crustal normal faults, mainly N-S trending, acting at different times and with different displacements during Jurassic time and during at least the Early Cretaceous (Fig. 4). The main Mesozoic tectonic features bordering the Belluno Basin are from west to east: the eastern margin of the Asiago Plateau, the Seren (Graben) Valley, the Cismon Valley alignment (clearly seen on satellite images), the Passo Rolle Line, the S Gregorio alignment, and to the east the Col delle Tosatte - Fadalto alignment (Figs 4 & 5). The Mesozoic alignments probably used inherited Variscan discontinuities as well. Platform and basinal Mesozoic facies do not coincide everywhere with the old horst and graben structure, i.e. the drowned Trento Platform, which acts as a horst with reduced basinal sequences after the Middle Jurassic until the Late Cretaceous.

Structure of the thrust belt

The geometry of the thrust belt is that of an imbricate fan (Fig. 3) with a main envelope angle produced by the thrust slices close to 7° (critical taper of wedge) according to the model of Platt (1988). The main thrusts are in order from the internal parts to the foreland, the Valsugana Line, the Belluno Line, the Moline Line, the Tezze Line and the Bassano Line. The thrust belt is not cylindrical in shape and the strain continuously changes along strike. In a map view of the area (Figs 2 & 5), the thrusts show an anastomosing pattern along strike, maintaining constant shortening which can conservatively be calculated as 30 km (Fig. 3).

The structural evolution of the thrust belt shows a general rejuvenation from the internal thrust to the external ones. However the internal thrust sheets seem to have been reactivated also in recent times (Sleyko *et al.* 1987). The crystalline basement outcrops in the hangingwall to the Valsugana thrust and is composed of Variscan metamorphosed greenschist facies rocks intruded by Late Carboniferous granitic bodies. Basement depth in the Venetian Plain is inferred by magnetic data (Cassano *et al.* 1986) and by the assumption of the general hinterland dipping monocline typical of thrust belts. This is consistent with the southward rising of the basement discovered in the Assunta Well at 4747 m where Late Triassic dolomites onlap a Late Ordovician

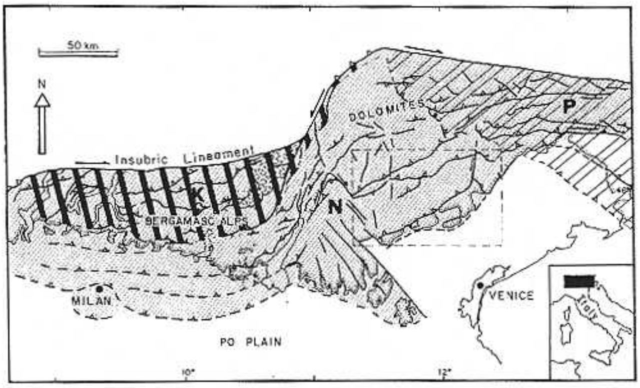

Figure 1. The Southern Alps underwent compressions at different times and in different areas. K: area of Late Cretaceous—Palaeogene compression; P: Palaeogene—Early Neogene compression (Dinarides); N: Palaeogene—Neogene compression (Southern Alps). The rectangle indicates the study area which has been deformed only by the SSE-vergent Neogene South Alpine thrust belt and was located in the foreland of the Palaeogene WSW-vergent Dinaric thrust belt. Note in the eastern side the overlapping between Southern Alps and Dinarides.

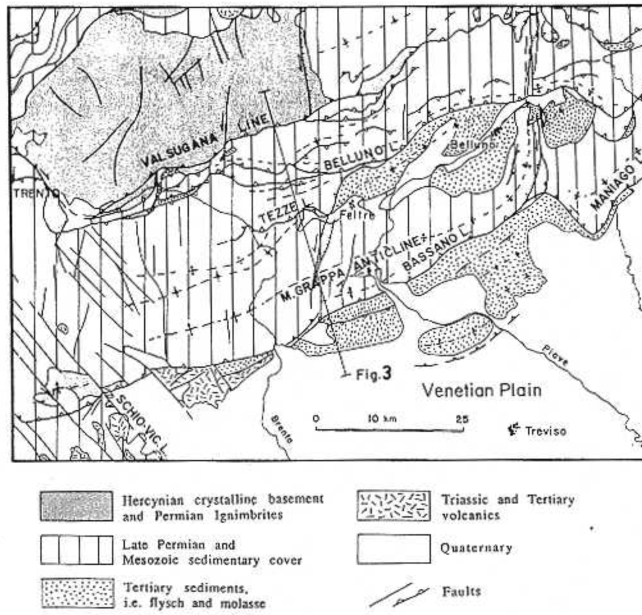

Figure 2. Simplified tectonic map of the Venetian Alps.

granite (Pieri & Groppi 1981). The basement is clearly involved in the Valsugana Line, but balanced cross-sections would indicate a wider involvement by southern thrusts as well. Significant thickness variations of the sedimentary cover and minor dips of the thrusts cannot be excluded and these could considerably increase the amount of shortening along the thrust belt (Roeder 1989). The main decollement of the thrust belt appears to be located in the basement (15-20 km in depth) beneath the Dolomites as suggested by the construction of balanced cross-sections (Doglioni 1987) and by focal mechanisms of earthquakes indicating low angle thrust planes (i.e. the Siusi event, Slejko *et al.* 1987). Triangle zones are present along the Valsugana thrust where the basement is sometimes wedged within the sedimentary cover, or it produces a triangle zone in the Valsugana Valley where the Valsugana thrust faces a north-vergent basement involved backthrust, to the north of the Asiago Plateau. Major undulations along the Valsugana thrust occur as a result of inherited features, i.e. the sinistral N-10°E striking transpressive undulation of Borgo Valsugana which occurs at an inherited structural high as indicated by the reduced thickness of the sedimentary cover. The thrust has a ramp trajectory and has not assumed a staircase geometry in the sedimentary cover, probably due to the difficulty in generating flexural slip folds.

Within the sedimentary cover the thrusts are characterized by cut-off angles ranging between 5° and 45°. Preferential decollement layers are the Tertiary Possagno Marls, the Late Cretaceous Scaglia Rossa, and other, buried levels within the Late Permian and Triassic sequences. The thrust planes assume steeper angles when a footwall syncline is present. Footwall synclines are well developed in Cretaceous pelagic thin-bedded rocks (Biancone and Scaglia Rossa) whose folding is accomodated by intense flexural slip. Chevron folds are particularly common in these two formations and their amplitude and wavelength decrease away from the thrust planes.

The frontal part of the thrust belt is characterized by a triangle zone (Figs 2 & 3) which generates a general southward dipping monocline characteristic of the Venetian foothills between Bassano and Vittorio Veneto. The frontal triangle zone is the most peculiar structure of the foreland and its presence is indicated by: (1) the general absence of an important thrust at the base of the mountains (Monte Grappa - Visentin Anticline); (2) the necessity of a thrust at the base of the anticline to resolve the volume problem of the structural high; (3) the south-dipping monocline in the frontal part of the chain which is typical for the triangle zones (i.e. Bally *et al.* 1966; Jones 1982; Boyer & Elliott 1982); (4) the presence of north-vergent backthrusts (i.e. in the Possagno and Follina areas, Braga 1970; Zanferrari *et al.* 1982). The interpretation presented in Figure 3 of the triangle zone is only one possibility: i.e. there are not clear indications of the southward continuity of the decollement necessary to adsorb the amount of displacement. This could be in turn expressed through pressure solution cleavage or more probably in antiformal stack duplexes within the antlicline core of the triangle zone.

It is interesting to note that a similar triangle zone has been reported for the northern part of the Alps in the Bavarian foreland (Müller *et al.* 1988). The triangle zone between Bassano (Schio?) and Vittorio Veneto seems to be connected with a ramp-flat geometry of the deep-seated blind thrust which generated a thrust-propagation fold (the Monte Grappa-Visentin Anticline). This was active at least during Late Miocene times because Tortonian and Messinian sediments onlap with a gradually smaller inclination the southern limb of the anticline (Massari *et al.* 1986). Sequence boundaries in the southern fold limb are marked by angular unconformities with decreasing angles toward the foredeep suggesting the coeval activity of the frontal fold (Monte Grappa - Visentin Anticline). It is clear that the unconformities are angular only along dip where the frontal fold is perpendicular to the assumed regional maximum Neogene stress (σ_1: N20°-30°W) and the fold axis has a 'cylindrical' trend. Where there are structural undulations in the fold axis (i.e. the sinistral transpressive zones of Valdobbiadene-Cornuda and the greater Fadalto alignment) the unconformities are marked by angular relationships along both dip and strike. In summary, structures control the nature of the unconformities. A growth fold, with constant horizontal axis, generated by pure compression produces angular unconformities only along dip, whereas a growth fold generated by transpression produces angular unconformities both along dip and strike.

To the north, the Belluno Line may have been a blind thrust generating a triangle zone during earlier stages of the deformation, later rising at the surface in the northern limb of the Belluno Syncline. This is supported by the steep attitude of the northern limb of the Belluno Syncline which is difficult to explain geometrically as a simple footwall syncline. It is also notable that triangle zones mainly occur in the Mesozoic Belluno Basin (Fig. 5), rather than in the neighbouring platforms. In fact the Belluno Syncline is developed in the deepest structural zone with thick basinal lithofacies. This earlier structural situation had an important influence in the morphology and source areas of the hydrographic pattern during the Late Miocene.

Timing of the thrust belt

In the Venetian segment of the Alps the thrusts became active during Late Oligocene to Quaternary times. Tortonian sandstones are thrust by the Valsugana Line (Venzo 1939) and Pliocene shales are folded along the frontal triangle zone. Moreover Messinian-Pliocene onlap geometries in the southern border of the chain support a mainly Neogene age of deformation. The extension of the unconformities within the molasse is a function of the thrust belt structure and reflects areas of stronger uplift. A problem is represented by the style and timing of the orogenic evolution: Has the thrust belt grown southward in a regular fashion by continuous creep since Late Oligocene time and do the unconformities record moments of sea level fall (low stand)? Or was the chain generated step by step so that the unconformities simply mark moments of tectonic activity? In general, plates move with a regular velocity suggesting that in areas of deformation the tectonic evolution should follow an almost constant activity. If the tectonic evolution generated with a constant regularity and tectonic activity had a wavelength too short or too long with respect to the eustatic sea level changes, then an interesting problem appears in dating the thrust belt: the timing of the tectonic activity has been considered as the time missing at regional unconformities and the age of coarse-grained sediment supply (i.e. the Messinian conglomerate) onlapping the

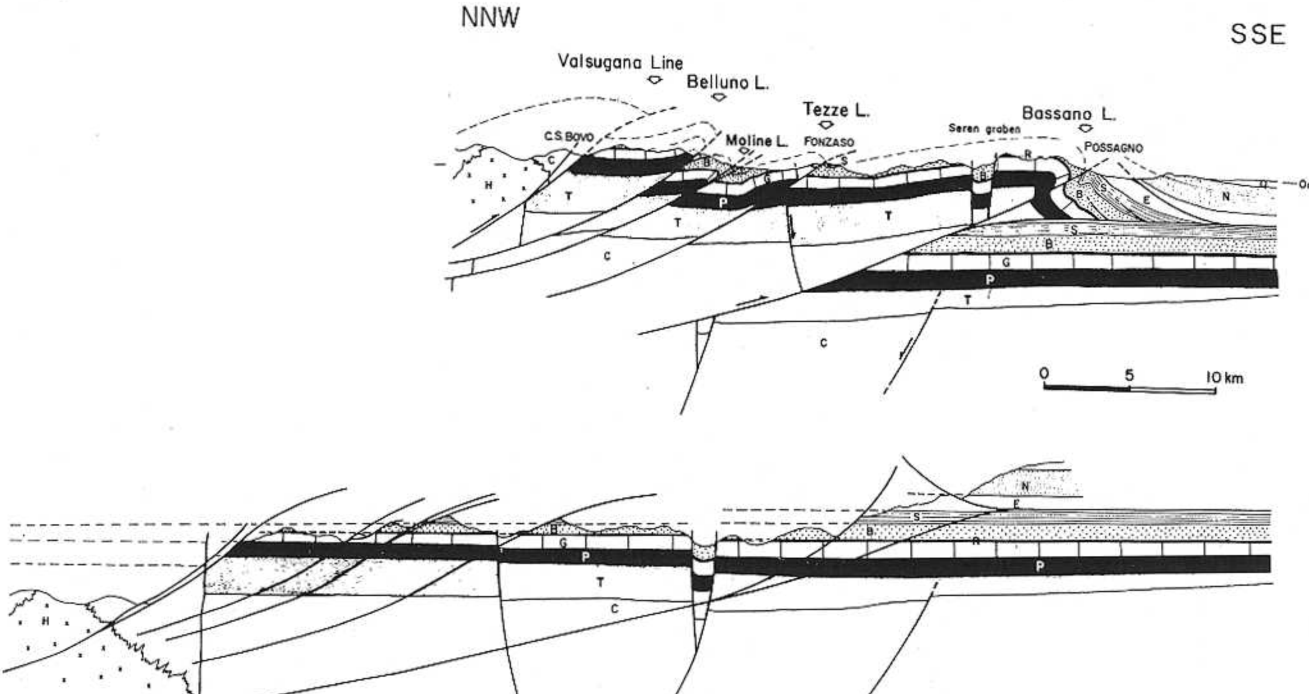

Figure 3. Balanced cross section across the Venetian Alps. See Figure 2 for location. Horizontal scale = vertical scale. Legend: C, crystalline basement; H, Late Hercynian granite; T, Late Permian-Lower and Middle Triassic formations; P, Late Triassic (Dolomia Principale); G, Liassic platform facies (Calcari Grigi) gradually southward passing to Liassic-Dogger basinal facies in the Venetian Plain (Soverzene Formation, Igne Formation, Vajont Limestone); R, Dogger-Malm basinal facies (Lower and Upper Rosso Ammonitico, Fonzaso Formation); B, Early Cretaceous (Biancone); S, Late Cretaceous (Scaglia Rossa); E, Palaeogene (Possagno Marls, etc.); N, Late Oligocene—Neogene Molasse; Q, Quaternary.

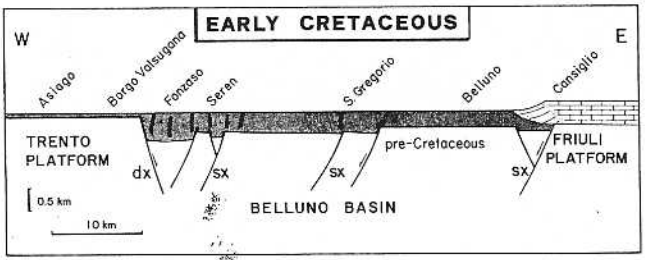

Figure 4. Interpreted W—E Early Cretaceous cross section from the Asiago plateau to the Cansiglio plateau, showing the coeval extensional tensional tectonics, which produced differential subsidence in the area. Note the basinward prograding carbonate platform in the eastern side (M. Cavallo Limestone) and the different thicknesses in the basinal sedimentation (Biancone). Neptunian dykes (vertically shaded) characterize the zones of tensional tectonics (i.e. the Arsiè Lake). The Neogene deformation has been strongly influenced by the pre-existing structural and stratigraphic geometries: dx and sx are dextral or sinistral transpressive or transfer zones which emplaced at the pre-existing anisotropies. Compare the general tectonics of the area with the inherited Mesozoic structural background (Fig. 5).

discontinuity. However, if the unconformities recorded only moments of general lowstand (in this case global or confined to the salinity crisis in the Mediterranean area) then one could argue that the thrust belt developed more gradually and that the sea level oscillations orchestrated the arrangement of the syntectonic sedimentary sequences. The different interpretations of the unconformities and conglomeratic supply in the molassic sequences allow different tectonic reconstructions. With the sea level change interpretation (Vail *et al.* 1977) the chain rises constantly during Late Oligocene-Neogene times, but if we assume the unconformities and conglomeratic supply to be tectonic-related, then episodic tectonic activity existed, which is in contrast to the regular activity of the frontal growth fold and the general plate motion.

In the Belluno syncline an angular unconformity marks the Early Eocene Flysch - Late Oligicene Molasse contact. Moreover the Flysch seems to onlap the northern limb of the Belluno syncline and to the west the Seren Valley alignment. Consequently it is not possible to exclude the interpretation that the area underwent compressive tectonics during Palaeogene times.

Interference pattern

The basement and the sedimentary cover of the region were broken by N-S trending normal faults and N60°-90°E transfer faults (the palaeo-Valsugana Line ? Fig. 3) during the Late Permian-Mesozoic rifting phases. These features have been cut, re-used or deformed during the Alpine inversion. Local structural undulations in the general N60°-80°E trend of the chain (fold axis, direction of thrust planes, etc.) everywhere occur in correspondence to inherited features in the basement and in the Mesozoic sedimentary cover which occurs in approximately N-S trending basins and swells. The present tectonic configuration is due to the inherited Mesozoic structure. The structural evolution of the area followed boundary features as transfer zones at horst margins (i.e. at the Trento Platform and Friuli Platform margins) which have influenced the geomorphological evolution of the area. The

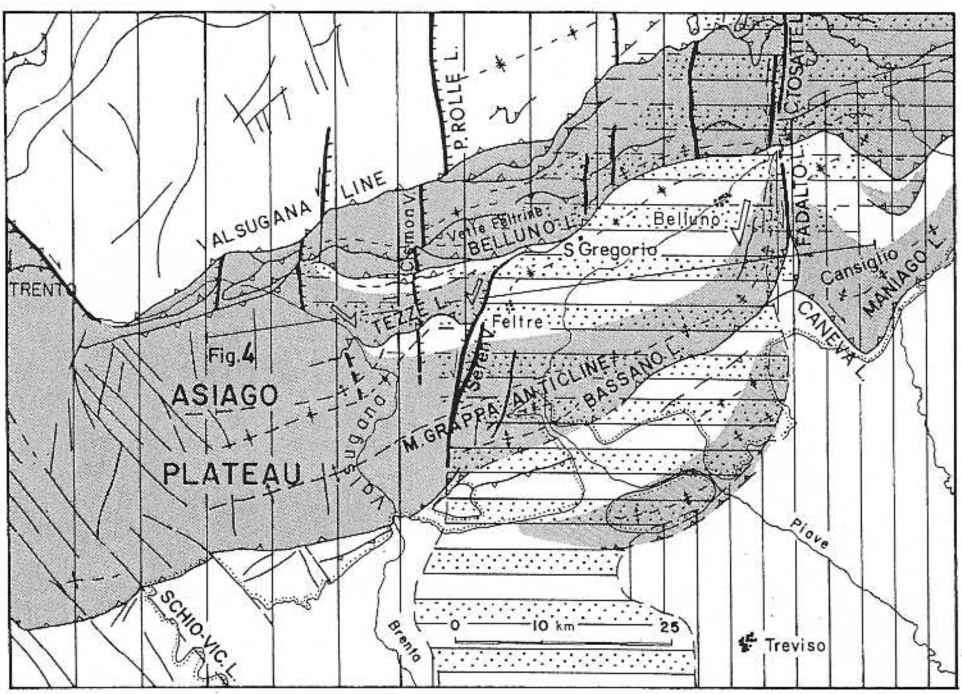

Figure 5. The Mesozoic basins and swells clearly controlled the geometry of the Venetian Alps thrust belt, resulting in axial undulations of the structures. Shadow, structural reliefs to the south of the Valsugana Line. Transpressive or transfer zones are located at inherited faults, thickness changes and facies transitions of the sedimentary cover. The relief of the Asiago Plateau—M. Grappa Anticline suddenly decreases in size when the deformation enters the Belluno Basin and eastward becomes a sinistral transpressive zone at the intersection with the Friuli Platform. Note how the structural reliefs are more diffuse within the inherited Belluno Basin. Compare Figure 4.

Asiago pop-up (Barbieri 1987) constitutes the western part of the study area, and is a wide plateau formed on the inherited Trento Platform (horst). The deformation at the western end of the Valsugana Line is transferred in the Trento area through the dextral transpressive Calisio Line (Fig. 2) to the sinistral transpressive Giudicarie Belt to the west. This undulation similarly runs around a minor inherited Late Palaeozoic and Mesozoic horst, within the wider Trento Platform. On the basis of thickness and facies changes the amplitude of the Trento Platform was probably wider in the east during Jurassic times (Seren Valley) and probably retreated (as horst, with basinal facies) by about 10 km during Cretaceous times (eastern margin of the Asiago Plateau, Valsugana Valley). The Tezze Line develops at this final eastern margin of the Trento horst and undulates in an oblique and lateral ramp (sinistral transpression) at the intersection with the inherited Seren Valley alignment (Fig. 5). The Alpine deformation within the Belluno Basin is more diffuse, characterized by a major number of thrust planes and reduced wavelength folds with respect to the lateral platform areas (Fig. 5). The Belluno Line mainly develops to the east of the Trento Platform. It branches the Valsugana thrust and shows an eastward increase in displacement and amplitude of the fault-propagation folding and fault-bend folding in the hangingwall. Commonly, the inherited tensional Mesozoic areas have been reactivated in transpressive zones (Fig. 4) and are transfer zones between two different styles of deformation. For instance the N-vergent backthrust in the hangingwall of the Belluno Line ends at the western margin of the Vette Feltrine at the intersection with the inherited tensional zone of the Cismon Valley (Fig. 5). The Caneva Line and the Fadalto Line are two respectively dextral and sinistral transpressive zones at the eastern margin of the Belluno Basin (Fig. 5). The Caneva Line represents the eastern transfer fault of the frontal triangle zone (Fig. 5). The Fadalto transpression was emplaced at the western termination of the Friuli Platform. The study area was located in the foredeep of the Dinaric thrust belt during Palaeogene times (Fig. 1) and suffered subsidence due to the load of the WSW-vergent Dinaric thrust sheets. A regional ENE-dipping monocline developed at that time and was inherited and involved in the younger SSE-vergent Neogene Southalpine deformation. The variations along strike of the deformation are reflected also in the Neogene and Quaternary foreland basin.

Conclusions

The good outcrops and the clear interference between inherited features and Alpine tectonics make the Venetian Alps a classic example of a thrust belt. Earlier Mesozoic features strongly influenced the evolution of the chain. Any kind of structural undulation along strike of the thrust belt is associated with pre-existing synsedimentary faults, thickness and/or facies variations in the sedimentary cover. The thrusts are arranged in an imbricate fan geometry and show a frontal triangle zone which was probably present at earlier stages of the thrust belt in more internal zones. The variations along strike of the deformation are reflected also in the Neogene and Quaternary molasse. The frontal triangle zone appears to be a growth fold from Late Oligocene to Quaternary time because clastic sedimentation on the southern limb of the anticline shows onlap geometries and reduced thicknesses. According to this progressive evolution of the thrust belt, the unconformities within the molasse could record lowstands of eustatic cycles.

Thanks to R. Crane and three anonymous referees who revised the paper. I also acknowledge K. R. McClay, A. Bally, G. Barbieri, D. Bernoulli, A. Bosellini, J. Channell, G.V. Dal Piaz, H. Laubscher, D. Masetti, F. Massari, I. Moretti, J. Platt, E. Semenza and E. Zappaterra for useful comments and discussions. The research was supported by an MPI grant.

References

Auboin, J. 1963. Essai sur la paléogéographie post-triasique et l'évolution secondaire et tertiaire du versant sud des Alpes orientales (Alpes méridionales; Lombardie et Vénétie, Italie; Slovénie occidentale, Yougoslavie). *Bulletin Société Géologique de France*, 7, **5**, 5, 730-766.

Bally, A. W., Gordy, P. L. & Stewart, G. A. 1966. Structure, seismic data and orogenic evolution of Southern Canadian Rocky Mountains. *Bulletin of Canadian Petroleum Geology*, **14**, 337-381.

Barbieri, G. 1987. Lineamenti tettonici degli Altipiani Trentini e Vicentini tra Folgaria e Asiago (Prealpi Venete). *Memorie Scienze Geologiche*, **39**, 257-264.

Bernoulli, D., Caron, C., Homewood, P., Kalin, O. & Von Stuijvenberg, J. 1979. Evolution of continental margins in the Alps. *Schweizerische Mineralogische und Petrographische Mitteilungen*, **59**, 165-170.

Bosellini, A. 1965. Lineamenti strutturali delle Alpi Meridionali durante il Permo-Trias. *Memorie Museo Storia Naturale Venezia Tridentina*, **15**, 3, 1-72.

—— 1973. Modello geodinamico e paleotettonico delle Alpi Meridionali durante il Giurassico-Cretacico. Sue possibili applicazioni agli Appennini. *In:* Accordi, B. (ed.) *Moderne vedute sulla geologia dell'Appennino*, Accademia Nazionale Lincei, **183**, 163-205.

—— & Doglioni, C. 1986. Inherited structures in the hangingwall of the Valsugana Overthrust (Southern Alps, Northern Italy). *Journal of Structural Geology*, **8**, 5, 581-583.

Boyer, S. E. & Elliott, D. 1982. Thrust systems. *American Association of Petroleum Geologists Bulletin*, **66**, 1196-1230.

Braga, G. P. 1970. L'assetto tettonico dei dintorni di Possagno (Trevigiano occidentale). *Accademia Nazionale Lincei*, **48**, 451-455.

Buxtorf, A. 1916. Prognosen und Befunde beim Hauensteinbasis und Grenchenbergtunnel und die Bedeutung der letzteren für die Geologie des Juragebirges. *Verhandlungen der Naturforschenden Gesellschaft in Basel*, **27**, 184-254.

Cassano, E., Anelli, L., Fichera, R. & Cappelli, V. 1986. Pianura Padana, Interpretazione integrata di dati geofisici e geologici. *Agip*, int. report, 1-27.

Castellarin, A. 1972. Evoluzione paleotettonica sinsedimentaria del limite tra 'piattaforma veneta' e 'bacino lombardo', a nord di Riva del Garda. *Giornale Geologia*, **37** (1970), s. 2, 1, 11-212.

—— 1979. Il problema dei raccorciamenti crostali nel sudalpino. *Rendiconti Società Geologica Italiana*, **1** (1978), 21-23.

Dal Piaz, G. 1912. Studi geotettonici sulle Alpi Orientali (Regione tra il Brenta ed il Lago di Santa Croce). *Memorie Istituto Geologia R. Università di Padova*, **1**, 1-196.

Doglioni, C. 1987. Tectonics of the Dolomites (Southern Alps, Northern Italy). *Journal of Structural Geology*, **9**, 181-193.

—— & Bosellini, A. 1987. Eoalpine and mesoalpine tectonics in the Southern Alps. *Geologische Rundschau*, **76**, 3, 735-754.

—— & Neri, C. 1988. Anisian tectonics in the Passo Rolle area. *Rendiconti Società Geologica Italiana*, **11**, 197-204.

Jones, P. B. 1982. Oil and gas beneath east-dipping underthrust faults in the Alberta foothills. *In:* Powers, R. B. (ed.) Geologic Studies of the Cordilleran Thrust Belt. *Rocky Mountain Association of Geologists*, 61-74.

Laubscher, H. P. 1983. The Late Alpine (Periadriatic intrusions and the Insubric Line. *Memorie Società Geologica Italiana*, **26**, 21-30.

—— 1985. Large scale, thin skinned thrusting in the Southern Alps: kinematic models. *Geological Society of America Bulletin*, **96**, 710-718.

Leonardi, P. 1965. Tectonics and Tectonogenesis of the Dolomites. *Eclogae Geologicae Helvetiae*, **58**, 1, 49-62.

Masetti, D. & Bianchin, G. 1987. Geologia del Gruppo della Schiara. *Memorie Scienze Geologiche*, **39**, 187-212.

Massari, F., Grandesso, P., Stefani, C. & Jobstraibizer, P. G. 1986. A small polyhistory foreland basin evolving in a context of oblique convergence: the Venetian basin (Chattian to Recent, Southern Alps, Italy). *International Association of Sedimentologists Special Publication*, **8**, 141-168.

Müller, M., Nieberding, F. & Wanninger, A. 1988. Tectonic style and pressure distribution at the northern margin of the Alps between Lake Constance and River Inn. *Geologische Rundschau*, **77**, 787-796.

Pieri, M. & Groppi, G. 1981. Subsurface geological structure of the Po plain, Italy. *Progetto Finalizzato Geodinamica*, **414**, 1-13.

Platt, J. P. 1988. The mechanics of frontal imbrication: a first order analysis. *Geologische Rundschau*, **77**, 577-589.

Roeder, D. 1989. South-Alpine thrusting and trans-Alpine convergence. *In:* Coward, M. P., Dietrich, D. & Park, R. G. (eds) *Alpine Tectonics*, Geological Society Special Publication, **45**, 211-227.

Slejko, D., Carulli, G. B., Carraro, F., Castaldini, D., Cavallin, A., Doglioni, C., Iliceto, V., Nicolich, R., Rebez, R., Semenza, E. Zanferrari, A. & Zanolla, C. 1987. Modello sismotettonico dell'Italia nord-orientale. *CNR, GNDT, Rendiconto*, **1**, 1-82.

Vail, P. R., Mitchum, R. M. Jr. & Thompson, S. III 1977. Seismic stratigraphy and Global Changes of Sea Level, Part 4: Global Cycles of Relative Changes of Sea Level. *In:* Payton, C. E. (ed.) *Seismic Stratigraphy - applications to hydrocarbon exploration*. American Association of Petroleum Geologists Memoir, **26**, 83-98.

Venzo, S. 1939. Nuovo lembo tortoniano strizzato tra le filladi ed il permiano a Strigno di Valsugana (Trentino meridionale orientale). *Bollettino Società Geologica Italiana*, **58**, 1, 175-185.

Winterer, E. L. & Bosellini, A. 1981. Subsidence and Sedimentation on a Jurassic Passive Continental Margin (Southern Alps, Italy). *American Association of Petroleum Geologists Bulletin*, **65**, 394-421.

Zanferrari, A., Bollettinari, G., Carobene, L., Carton, A., Carulli, G. B., Castaldini, D., Cavallin, A., Panizza, M., Pellegrini, G. B., Pianetti, F. & Sauro, U. 1982. Evoluzione neotettonica dell'Italia nord-orientale. *Memorie Scienze Geologiche*, **35**, 355-376.